SPECIFIC GRAVITY IN SPINAL ANESTHESIA

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WHILE spinal anesthesia is becoming more and more popular, many of the medical profession would still refuse it for themselves and for their patients. Since detrimental after-effects have not been definitely established in many thousands of cases, this refusal must be based on a fear of the technique itself. While the procedure is simple in itself, a complete knowledge of all the factors is imperative. If the profession could visualize just what takes place in the spinal canal, their understanding of the procedure would be greatly increased. It was for this purpose that these experiments were done, accurate in principle and far simpler than the studies on dogs and cadavers.

FUNDAMENTAL PHYSICAL FACTORS

A few fundamental physical factors will be stressed which have not been emphasized sufficiently before. These factors are based on the specific gravity of the solutions involved. As early as 1907, the specific gravity of the anesthetic agent was augmented to 1.030 and 1.080 by the addition of dextrose and saline. Some twenty years later Pitkin developed an agent of specific gravity less than that of spinal fluid. The importance of specific gravity has been considered and discarded from time to time. The present experiments may aid in explaining failures of the past and in avoiding failures in the future.

A simple laboratory experiment will effectively demonstrate the rôle of specific gravity in controlling the anesthetic level obtained. An artificial spinal canal is readily made from a piece of glass tubing two feet long and of sufficient caliber to contain fluid equivalent to that in the spinal canal—60 cubic centimeters. (This amount varies in the canal and has not been established.) One end of the tubing is bent upward to form a reservoir representing the cranial cavity, and to produce pressure. A short segment at the other end, joined by a piece of rubber tubing, permits the punctures to be made. For accuracy, the cervical, thoracic, and lumbar curves are added, but these are not essential in demonstrating the principle. This canal is filled with dextrose-saline solution of specific gravity equal to that of spinal fluid—in the absence of spinal fluid itself. The anesthetic agent is colored with a drop of methylene blue.

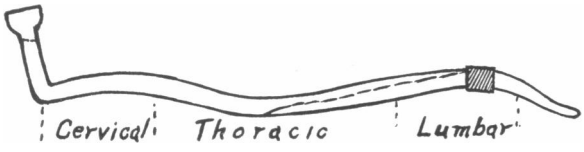

Fig. 1.—The glass canal with Novocain solution.

ANESTHETIC SOLUTIONS

Three groups of anesthetic solutions are considered:

1. Those lighter than spinal fluid, specific gravity less than 1.005 ±. These include spinocain and aqueous solutions of novocain of less than 2½ per cent.

2. Those approximately the same as spinal fluid, specific gravity 1.004-1.008. These include nupercain (0.5 per cent of the agent in buffered solution) specific gravity 1.003; pantocain 1 per cent in 0.67 per cent saline solution, specific gravity 1.0068; and aqueous solutions of novocain of 2½ per cent, specific gravity 1.005.

3. Those heavier than spinal fluid, specific gravity greater than 1.005 ±. These include all solutions of novocain crystals in spinal fluid, gravocain, and nupercain or pantocain, to which novocain crystals have been added. The specific gravity will vary with variations in amounts of crystals or solution used.

While the specific gravity of the spinal fluid will vary in different individuals, or with the state of hydration or disease, this variation is negligible in comparison with the wide variations in the specific gravity of the anesthetic solutions; especially so when spinal fluid is used as the solvent. The volume of spinal fluid and the pressure will vary, but can have little bearing. The final specific gravity of the injected fluid is the only factor to be considered in determining the amount to be injected and the subsequent posture of the patient. Those who routinely dissolve 200 milligrams of novocain crystals in 2 cubic centimeters of spinal fluid must depend entirely on posture to control the level; the resultant 10 per cent mixture flows too rapidly in the canal to be easily controlled. The agents giving prolonged anesthesia are of definite value, but they cannot be given with the same technique used for novocain crystals, if the level of anesthesia is to be under control.

RESULTS NOTED

1. Spinocain: When the canal is level, the anesthetic solution rises to the top of the tube and slowly spreads out in both directions, leaving the lower half of the tube clear. Thus, with the patient placed immediately on his back, motor paralysis, but little sensory change, may be produced. With the "head" elevated 15 degrees, the anesthetic is all in the reservoir in less than ten minutes, leaving the entire canal clear. When elevated only slightly the anesthetic spreads upward rapidly. A study of the spine in the lateral view, or a glance at the diagram shows that there are no obstructing curves for floating solutions until the upper cervical region is reached, and then only a slight curve. With the head lowered 15 degrees, the solution accumulates in the caudal end of the canal, diffusing too slowly to reach satisfactory levels before the agent is fixed or inactivated by the tissues.

2. Nupercain and pantocain: These solutions behave in much the same manner, pantocain being slightly the heavier. Diluted with spinal fluid be-

fore injection, the specific gravity approximates that of the fluid itself, and the agent remains practically stationary when the tube is tilted. Diffusion during fifteen minutes is very slight. Thus the level will depend on the volume injected; the posture of the patient and the angle of the table will have little, if any, influence. Is this perhaps the explanation for the fewer unfavorable reactions seen with these drugs than observed with novocain? They do not drift, therefore are not so likely to reach the higher levels.

3. Solutions of novocain crystals in spinal fluid: The specific gravity of these solutions varies with the concentration, reaching 1.025 when 200 milligrams are dissolved in 2 cubic centimeters of spinal fluid (10 per cent). The addition of nupercain or pantocain makes no difference—all are heavier than spinal fluid unless used in aqueous solution. Therefore, they drift when the tube is tilted. The rapidity of the drift is proportional to the concentration, and depends also upon the angle of the tube: 2 cubic centimeters of a 10 per cent solution will reach as high a level as 8 cubic centimeters of a 2½ per cent solution, with the "head" lowered. These solutions layer along the lower portion of the canal, reaching sensory rather than motor nerves. There is an added factor of safety provided by nature when these solutions are used: drifting along the posterior surface of the canal, their spread is inhibited by the upward curve of the canal in the midthoracic region. Unless the table is lowered too acutely, the anesthetic will accumulate in this region and go no higher. Does this not explain why so many of these anesthetics stop at the costal margin or nipple line? The thoracic curve should be given more credit for the small number of high levels which are seen. Therefore, increase this curve by placing the head and shoulders on a pillow. Mechanical dilution, as the anesthetic spreads, is the only other factor of safety. When the anesthetic has become fixed, the Trendelenburg position may be used and is desirable. When punctures are made with the patient horizontal, the downward curve or inclination of the canal may also be a factor in starting this drift.

4. The needle bevel: In these experiments it was found that the direction in which the bevel of the needle pointed made little difference when the injection was slow. When the solution was injected rapidly, or when a needle of small caliber was used, the anesthetic could be forced in the direction the bevel pointed. If spinal fluid pressure has any bearing, it is on this factor.

5. Diffusion and dispersion: By layering spinal fluid and the various anesthetic agents in test tubes, the rate of diffusion was studied. In fifteen minutes the amount was hardly perceptible, while in two hours it was insignificant. The higher concentrations of novocain showed a greater diffusion, as should be expected. The spinal canal is not a test tube and the spinal fluid is not entirely without circulation. The dispersion of the anesthetic agent may be increased by movements of the patient, especially flexion or extension of the spine. Pulsations of regional vessels may set up small currents which favor dispersion. On the other hand, branching nerves may interfere with the fluid dispersion, or with its flow due to specific gravity. Proper technique should avoid unnecessary motion of the patient.

CONCLUSIONS

1. The specific gravity of the agent used in spinal anesthesia is important, and must be considered in giving safe anesthetics.

2. An anesthetic agent of specific gravity greater than spinal fluid is desirable because: (*a*) The effect is primarily sensory; (*b*) the level may in part be controlled by the angle of the table; (c) the natural curves of the spine and canal inhibit the flow of the agent to higher levels.

3. The spread of the anesthetic agent by diffusion is insignificant.

4. Since the spinal canal varies in diameter at different levels, the height reached is better controlled by drift than by volume injected.

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DISCUSSION

C. D. LEAKE, Ph.D. (University of California Medical School, San Francisco). — My qualifications are such that I may attempt to discuss only those portions of Doctor Bingham's interesting paper which relate to the drugs he mentions. To begin with, it is high time that the medical profession realized the tremendous importance of the names of drugs. Commercial pharmaceutical houses frequently take advantage of the ignorance of physicians with respect to chemistry by disguising, under a readily remembered trade-marked name, a common chemical or mixture of chemicals which then may be exploited at exorbitant prices. The names of chemicals given in the United States Pharmacopeia are public property, and it is in the interest of public welfare to use these names, and these names only, when referring to the chemical to which they are applied. Thus, "Novocain" is the trade-marked name, owned exclusively in the United States by the H. A. Metz Laboratories, Inc., for the chemical described in the United States Pharmacopeia as procain. Since procain is the public name, its general use by physicians would tend to keep the chemical described under this name on an open competitive basis so that no unreasonable prices may arise from the exploitation of a trade-marked name. "Spinocain" is also a trade-marked name, owned exclusively in the United States by the H. A. Metz Laboratories, Inc., and it is given to a mixture of salts of procain and strychnin with starch. There is no pharmacological reason whatsoever to include strychnin in a local anesthetic solution, and it is extremely doubtful that the addition of starch produces changes in specific gravity which are sufficiently pronounced to prevent diffusion and flow of the mixture in spinal fluid in the body. Dr. G. B. Pitkin, who is said to have developed "Spinocain," seems to specialize in the promotion of peculiar mixtures of drugs which the H. A. Metz Laboratories, Inc., have trade-marked to exploit to physicians (*Journal of the American Medical Association,* 99:936, September 10, 1932). "Gravocain" is a new one for which I can find no reference in reliable medical literature, but I expect that it is a trade-marked name of a slight variant of a starch and local anesthetic mixture similar to "Spinocain." In order to make any chemicals available for medical use, it is necessary to give some commercial protection to the company first undertaking to manufacture them. This is customarily done by patenting the chemical, and usually by trade-marking it at the same time. The patent rights expire after seventeen years, when anyone may compete in the manufacture of the agent. Unfortunately, however, the trade-mark is indefinite.

Trade-marked names are the only ones possible for patented drugs. As soon as the patent expires, however, a public name should be given to the drug, if it is a useful one, in the pharmacopeia, and then physicians should only use the public name. "Nupercain" is the trade-marked name of a patented quinin derivative developed by the Ciba Company, Inc., and until the patents on it expire it can have no other name. "Pantocain" is also a trade-marked name for a patented local anesthetic of the procain series, and again no other name can be used for it until the patents expire.

The pharmacologic evaluation of local anesthetics is a long and tedious task. Clinicians do not always examine such scientific studies with the care which they deserve. Usually the clinician relies upon the advertising material distributed by the company interested in exploiting the local anesthetic. It is doubtful if any new local anesthetic can be demonstrated to be superior to procain for spinal anesthetic, because of its almost unique wide margin of safety between the effective anesthetic dose for nerve tissue on local application and the dosage required for toxic effect.

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THOMAS A. CARD, M. D. (Glenwood Building, Riverside).—Doctor Bingham has pictured very graphically the dissemination of anesthetic agents when injected into the spinal canal. The relation of specific gravity of these agents and the posture of the patient is also beautifully illustrated. This experimental work bears out the clinical findings of Maxson in CALIFORNIA AND WESTERN MEDICINE, November, 1933.

The control of spinal anesthesia levels has been one of the big problems in this field of anesthesia. Many surgeons are slow to adopt a method so adaptable and so safe for many operations because of the feeling of insecurity in controlling the anesthetic. For some months, in my service at the Riverside County Hospital and in my private practice, I have followed the principles as set out in this paper, and I have found that the anesthetic level has been more accurately controlled than by the technique previously used.

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C. VAN ZWALENBURG, M. D. (308 Citizens National Bank Building, Riverside).—This clever device makes a very clear demonstration of the important factors controlling the degree and the level of anesthesia.

The colored fluid is easily followed with the eye, and shows definitely the rate, the extent and the direction of its diffusion.

If those using spinal anesthetics will repeat this demonstration, their ability to locate and limit the degree and extent of anesthesia will be greatly advanced, and the safety of the patient more nearly insured.

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DOCTOR BINGHAM (Closing).—Doctor Leake has called attention to a rather common error made in discussions and literature on procain anesthesia. We have been using novocain clinically and experimentally. Gravocain was also developed by G. B. Pitkin in a manner similar to spinocain, but heavy as the name implies. It is also marketed by H. A. Metz Laboratories, Inc., and was intended for use in obstetrics where the Trendelenburg position is undesirable. The only objection to novocain or procain anesthesia is its limited duration.

Nothing has been said regarding anesthetics administered with the patient in a sitting position. It is a technique which we have not used. If the anesthetic solution is heavier than spinal fluid, it falls to the base of the canal and must be disseminated from this point. For anesthesia limited to the rectum and perineum, it should be the procedure of choice. Obviously, the sitting posture must not be used with anesthetic solutions lighter than spinal fluid.

THE PROBLEMS OF OBESITY*

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DISCUSSION *by Lovell Langstroth, M. D., San Francisco; Bertnard Smith, M. D., Los Angeles; Fletcher B. Taylor, M. D., Oakland.*

"Leave gormandizing; know the grave doth gape
For thee thrice wider than for other men."
Shakespeare, *Henry IV.*

THE lay person is concerned with overweight largely from the standpoint of appearance and the fashion of slenderness, but to the physician it is a problem of disease and life expectancy. It is hardly necessary to dwell on the dangers of obesity to a medical audience. It will suffice to mention structural and postural strains, increased hazard in infectious diseases, shortening of life span, associated mental and emotional disturbances, increased incidence of gall-bladder disease, disturbances in cholesterol metabolism and, above all, the relation to cardiovascular disease. There is, indeed, an opportunity for meditation on this latter point, if the recent claims of von Zorday[1] are correct: that in the light of the more modern and delicate methods, 90 per cent of obese patients show evidence of injury to their circulatory apparatus. There can be little doubt of the important rôle that overweight plays in the ever-increasing death rate due to the so-called degenerative diseases, particularly hypertension, myocardial damage, and diabetes.

The present-day real problems of obesity are related to its cause or causes. It is altogether probable that, in understanding the etiology of overweight, we will have a proportional increased insight into the causes of the associated degenerative diseases.

We have approached the problem largely from the standpoint of the energy balance. There is nothing that throws any doubt on the validity of applying the basic laws of energy to the problem of weight. It is presumptuous to disregard the first and second laws of thermodynamics, and state that certain subjects could not be reduced by an adequate diminishing of caloric intake; and yet this statement is frequently made or implied even in present-day literature. Obesity is demonstrably a condition in which the caloric intake is in excess of the maintenance requirement.

METHODS

Our studies for the past few years have concerned themselves primarily with the determination of the maintenance requirement in underweight and overweight. Chamber calorimeter measurements in the past have been inadequate, inasmuch as exact living conditions could not be duplicated for sufficiently long periods of time. We have used the following two methods in which the living conditions were not disturbed and the energy

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